EMOTIONAL AWARENESS IN VIRTUAL HUMANS WITH CASE-BASED REASONING

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ABSTRACT

In order for virtual humans to become emotionally intelligent, they must have the ability to detect emotions within humans. A comparison on the usefulness toward this goal is made between appraisal and feeling emotion theories and between Bayesian networks and cased-based reasoning (CBR) to implement am emotion model. Feeling theory implemented using CBR is tested to evaluate the effectiveness of the representation in determining an emotion from a given input.

INTRODUCTION

As computers grow more complex and integrated into human lives, people will require a better means of interacting with them. From this necessity the study of affective computing has been created. The MIT Media Lab's Affective Computing Group defines affective computing as "computing that relates to, arises from, or deliberately influences emotion or other affective phenomena."[8] The idea is to create computers with emotional intelligence, or the ability to manage emotion through detecting, identifying, reacting, and expressing emotion. Giving computers the ability to cope with emotion will allow them to satisfy human needs at a level unachievable before.

The work described in this article is the creation of an emotionally intelligent virtual human that will occupy a smart home environment. The goal is to have the virtual human be able to interact with inhabitants in a way that provides emotional support. This is a particularly important pursuit for the older generation who become less mobile and has a harder time experiencing meaningful social interaction.

The first step in the process is to create a virtual human that can identify the emotional state of an inhabitant. If an inhabitant and a virtual human are to have a dialogue that reaches an emotional level, then both parties require the ability to identify the emotions in each other. This "hearing" of each other's emotions achieves a new degree of communication. For a human, this is a natural ability that comes with experience in communication. For a virtual human, this requires an underlying system for emotional intelligence. To move towards this goal, a virtual human must identify emotions. A first step is to evaluate current emotion theories and methods for modeling them.

EMOTION MODELS

In order to identify emotions within a person, an appropriate model for them must be established. This model needs to define what causes an emotion and what observable characteristics of a person can be used to identify one. Two of the most widely used theories for emotion are appraisal and feeling theory. A comparison of these two theories is necessary to determine which would be better suited for a virtual human. However, an emotion theory alone may not be enough for a virtual human. To add a deeper level of understanding, a personality model may be used as well.

Researchers use and implement a variety of models for emotion such as appraisal theory. According to appraisal theory, emotions are a response to an evaluation of the progress a person has made towards his or her goals.[2] Appraisal theory gives a deeper understanding of a person because it concentrates on his or her perspective in the situation. A person does not have an emotional response to a stimulus until he or she realizes and interprets the stimulus[4]. The emotional output from the appraisal may change depending on how perceptive the person is at the time. So, in order to understand a person's reaction to an event, the virtual human would have to understand the person's perspective, values of items within the situation, and interpretation of events in the situation. If a virtual human could understand these aspects of a person, then essentially the person is already understood. The virtual human can only infer the emotions of an inhabitant through external output of the person. Anything else is merely speculation. Also, using appraisal theory does bring in the complications of identifying the goals of a person and then evaluating progress in meeting those goals. Appraisal theory is a very effective means of gaining a greater understanding of the motives of a person, but the information required to use it adequately to detect emotion may be outside current abilities.

Currently, the most viable theory to use to map emotion is feeling theory (also known as James-Lange). Under feeling theory, emotion is a result of the physiological reaction within a person from an event.[2] Therefore, a person's emotion can be inferred by measurements of a person's body language, internal biological functions, and verbal response. However, many emotions closely overlap, so distinguishing them from one another is difficult[4]. As the tools become more sophisticated, they may be able to place the input more in context of the situation, but even at their current level feeling theory is an appropriate model for creating an emotionally intelligent virtual human.

A consideration for the future is using personality types as a secondary model of emotion. A person's personality influences their behavior and typical emotional responses. One of the most recent personality models is the Five Factor Model (FFM). The FFM describes every person's personality in five different dimensions. The dimensions are: extraversion, neuroticism, conscientiousness, agreeableness, and openness.[5] With a basic understanding on how an inhabitant rates in these dimensions, a virtual human can better understand the uniqueness of the person. These personality types can be used to form a model of the inhabitant, and give more meaning to his action. For instance, one person may be more neurotic than another. The virtual human would then understand that the neurotic person complains and worries more than others, and may even dismiss the minor complaints. However, if the less neurotic person passionately complains about something or become distraught by it, the virtual human gives the event a higher amount of importance than if it would for the neurotic person. Personality gives the virtual human the ability to establish a context around an emotion within a person.

IDENTIFYING EMOTIONS

With a decision on using feeling theory to model emotion and possibly FFM for personality, a method for the virtual human to identify an emotion needs to be determined. A Bayesian network is one of the most popular implementations of emotion models, but there are some shortfalls in the flexibility. A similar, but more appropriate method would be using case-based reasoning to determine the emotion.

A Bayesian network is used to map the probabilities of an outcome given the context of the situation. What parts of the situation that is examined depends on the implementation. Cavalluzzi, et al determined an emotion in a virtual human using the chances of success of its desired goals from the outcomes of an event.[3] Implementing a Bayesian network with feeling emotion theory would mean determining emotions through the context of the physical, measurable cues of a person such as body language and facial expression. Most of the previous research examined implementing a Bayesian network such as Cavalluzzi, et al and Kshirsagar, et al were used to display emotion in a virtual human.[3,6] However, Cavalluzzi believes that this method could be used to interpret the underlying goals that cause an emotional response from a person.[3]

A Bayesian network is an extremely powerful representation and reasoning strategy, but may have weaknesses in this domain. The literature discusses the careful handcrafting of initial models, but work in this area does not seem to include provisions for adaptation. The purpose of this virtual human is to be a companion to a person over a long period of time. This of course will mean that the virtual human will have to adjust and relearn as an inhabitant changes over time. Essentially, the virtual human will be living with an inhabitant and must deal with all of the emotional complexities of a person.

For identifying emotion with feeling theory, a CBR strategy was tested. A CBR approach is more appropriate for a smart home environment. Riesbeck states that the strength in a CBR is the ability to find solutions in similar problems with a variety of differences within them.[9]

The virtual human assisting an inhabitant must adapt to a wide range of interactions and events that occur in the everyday life of a person. Luger says that CBR has a powerful ability to learn, an ideal ability for dynamic problems.[7] Using CBR gives the virtual human the flexibility to detect the changes of behavior of a person over time, the subtle differences of emotion among different people, and the ability to diagnosis a new emotion in a new experience by matching it with a similar emotion from previous data. A CBR tool has the versatile capabilities needed to be used with an inhabitant through his everyday life.

Currently, investigation into which set of emotions should be identified and what characteristics can be used to identify them is being done. Much other work uses the Ortony, Clore, and Collins model, with some augmenting this theory with an additional two emotion states.[5]

IMPLEMENTATION

The CBR tool that was tested is the Case-Base Reasoning Tool v2.45 from Artificial Intelligence Applications Institute by Richard Wheeler and licensed by the University of Edinburgh.[1] It is an application that reads its case bases and test cases through text files. Through a method selected by the user, the tool compares a current case with the casebase and comes to a conclusion on a final, pre-selected goal.

The test of the CBR used randomly generated data for four emotions: happy, sad, surprised, and angry. Each case of an emotion was rated on three different scales from one to eleven meant to represent different qualities of verbal input: volume, speed, and quantity. Every case also had two Boolean values: cursing and crying. To generate the data, every emotion was given a bell curve with its center on a specific point in the scale, and a percentage chance for the Boolean values. This data was to represent the cues that signify the emotion of a person. See Table 1 for an example person that the generated data was based on. For added difficulty, the emotions were highly overlapping to test the CBR, but were at least distinct from one another on one scale.

Person A	Volume	Speed	Quantity	Crying	Cursing
Happy	6	8	2	15%	15%
Anger	8	7	3	5%	80%
Surprise	7	4	6	5%	60%
Sadness	2	3	3	80%	10%

Table 1. An example showing the verbal cue features and probability of each in determining an emotional state.

From this example person, one thousand base cases were randomly generated to represent the person's emotion at the time. Then eleven more cases were generated to test the data. Table 2 shows the eleven test cases that were generated and the format the cases are generated. Emotion tells which emotion the numbers were generated from and gave the CBR a variable to match, but were not used in the comparison process. Each variable of a case was evenly weighted to determine the emotion.

Name	Volume	Speed	Quantity	Crying	Cursing	Emotion
0Ang	9	8	3	NO	YES	Angry
1Ang	9	8	6	NO	YES	Angry
2Hap	6	9	5	NO	NO	Happy
3Hap	7	7	7	NO	NO	Happy
4Sur	6	5	4	NO	YES	Surprise
5Sad	1	5	4	NO	NO	Sad
6Sad	2	4	1	YES	NO	Sad
7Hap	6	5	6	NO	NO	Happy
8Sur	6	5	4	NO	NO	Surprise
9Sur	7	4	1	NO	YES	Surprise
10Sur	7	4	1	NO	YES	Surprise

Table 2. The test cases that were generated.

The CBR was extremely successful in identifying emotions with 81% accuracy. Table 3 shows the output from the CBR and which cases were falsely identified. For 4Sur, notice how quantity, the most distinctive difference between surprise and anger, was closer to anger than surprise. For 8Sur, the Boolean value for cursing is different from a typical case of surprise, so it most likely instantly lost 20% of its possible weight. These are examples of times when the case was out of line with the typical case of that emotion and appeared to be a different emotion. This of course, confused the system which then gave an incorrect result. However, with more values to determine an emotion, such as facial movement recognition, the emotions will grow more distinct and the CBR will become more accurate.

The drawback for using a CBR is that it needs a substantial base of information before it can be truly effective. A set of base cases to feature a wide range of emotions needs to be created. First, a set of emotions to identify needs to be defined, as well as what features will define each case. Afterwards, there is the matter of how much data is needed. This test did not check for the accuracy over different sizes of case base sets, but from a thousand case bases the CBR was quite accurate.

The CBR is currently stand-alone, but integration into a smart home environment and a virtual human is a goal. The main goal of integration for the CBR is to get input from the environment's cameras and natural language processor. The camera input will allow the CBR to recognize physical facial cues of an inhabitant and derive emotional meaning from it. Likewise, using the microphones and natural language processor in the smart home will allow the extrapolation of data for the CBR from the verbal output of an inhabitant. Once the CBR has diagnosed the inhabitant's emotion, it will then output it to a virtual human that will react to this newly determined emotion.

Rec	Goal	Result
0Ang	Angry	Angry
1Ang	Angry	Angry
2Hap	Happy	Happy
3Hap	Happy	Happy
4Sur	Surprise	Angry
5Sad	Sad	Sad
6Sad	Sad	Sad
7Hap	Happy	Happy
8Sur	Surprise	Happy
9Sur	Surprise	Surprise
10Sur	Surprise	Surprise

Table 3. The results of the CBR on the test cases. Goal shows the emotion the data was generated from and result shows the emotion the CBR guessed to be.

CONCLUSION

From the research, a complementary emotion model and implementation were selected. Feeling emotion theory allows a person's emotions to be determinable from measurable external output from the person. A CBR approach to determining the emotion gives the flexibility to relearn a changing personality. A CBR tool was tested to see if this was a reasonable approach, and the results were reassuring enough to continue with further research.

The first step for creating an emotionally intelligent virtual human is for it to recognize emotion. With the use of equipment most likely to already be in a smart home environment and the CBR, the completion of the first step comes closer. However, there is still work to be done in this process. The details now need to be defined. An establishment of a set of emotions and what characteristics signify them is needed. The tools are ready to be used, but knowledge how to use them is to be determined.

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